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ABSTRACT

The work described here forms part of a project using models of musical ideas within an artificial intelligence and education framework whose goal is to encourage and facilitate music composition by novices. Formal knowledge of the domain (popular music) is too incomplete and fragmented to support a traditional expert-based tutor for precisely constrained tasks with clear-cut rules. Instead the proposed system will try to construct teaching plans on the basis of what novices can do, and equally importantly, what they like, in order to help them find paths to personally important goals. As well as an attempt to tackle the stringent demands of the particular domain, the research is an exploration of whether it is possible to tutor effectively with incomplete knowledge in a complex domain. A 20-item reference list is included. (Author/DB)

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A knowledge-based tutor for music composition

Abstract

The work described here forms part of a project using models of musical ideas within an AI and education framework whose goal is to encourage and facilitate music composition by novices. Formal knowledge of the domain (popular music) is too incomplete and fragmented to support a traditional expert-based tutor for precisely constrained tasks with clear-cut rules. Instead the proposed system will use a net of disparate, incomplete knowledge sources linked with a small number of microworlds. The proposed system includes a new microworld for harmony, based on recent cognitive theories. The knowledge-based component will take the form of a net of objects corresponding to knowledge about pieces of music, musical styles and the musical strategies and techniques employed in them . The net is connected by links of generality, specificity and similarity. The proposed knowledge base is intended be explored in its own right, used to transform and generate fragments of music and used to guide discovery in the microworlds. The system will try to construct teaching plans on the basis of what a novice can do, and equally importantly, what he likes in order to help him find paths to personally important goals. As well as an attempt to tackle the stringent demands of the particular domain, the research is an exploration of whether it is possible to tutor effectively with incomplete knowledge in a complex domain .

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A knowledge-based tutor for music composition

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This is an extended abstract of a paper that was presented at the 3rd International Conference on Artificial Intelligence and Education, Pittsburgh, Pennsylvania 9th, May 1987. This version was prepared Nov 86 with minimal revisions made June 87. A more detailed and fully revised version of the paper including details of work carried out since Nov 86 is in preparation .

Introduction

The work described here forms part of a project whose goal is to find ways of using AI models of music composition within an AI and education framework to encourage and facilitate music composition by musical amateurs. We describe here design considerations for a knowledge-based ICAI system that tries to construct teaching plans on the basis of what an amateur can **do** musically, and equally importantly, what music he **likes,** in order to help him find paths to his chosen musical **goals.** Because knowledge by itself is not enough, musical **experiments** and experiences need to be made available. The system has components for the direct manipulation of harmonic and rhythmic materials, and for assembling and combining musical devices built out of these materials. These are designed to be accessible to non-expert musicians without instrumental skills.

1 Some possible teaching strategies for composition

Let us imagine someone who is musically uneducated and wishes to compose music but doesn't know how to set about it. Equally we can imagine someone with a traditional or idiosyncratic music education who can't compose. A human tutor might begin by focussing on three questions.

a/ What sort of music the amateur wants to compose.
b/ What sort of music the amateur likes or is interested in.
c/ What musical skills the amateur presently possesses.

The teacher might dynamically construct a teaching plan and exercises tailored to that amateur's likes and capabilities while making reference to a core curriculum of generally useful compositional strategies, techniques and materials. One teaching strategy might be to provide intermediate goals based on the amateur's self-expressed preferences in music as given in answer to the initial questions. A human teacher might say "The student wants to compose like (say) Steely Dan, so he is going to need to know about voicing 9th, 11th and 13th chords, about using cycle of fifths progressions, about transient modulation, about use of rhythmic motifs, melodic trajectories (Levitt, 85), and so forth. He doesn't know about any of this yet. We could start with a simple blues, and then look at some simple Jazz standards using cycles of fifths...". This approach appears reasonable, provided the student is willing to settle for them as enjoyable substitute goals for the time being, or is convinced of the relevance of the intermediate steps to reaching his goal. A contrasting strategy would be to say " Composing like Steely Dan is beyond this student's capabilities as yet, but by playing with these simple components he could get a very rough approximation right now". A reasonable combined strategy might be to offer the amateur at all points a free choice between these two strategies (personally meaningful intermediate steps or immediate rough and ready results).

2 Domain Knowledge

The system is to specialise in fairly limited areas of popular music and Jazz, but needs a base of knowledge common to most Western tonal music. (In principle it could be extended to deal with other kinds of music wherever appropriate music analysts and teachers could be found.) Several quite different layers of domain knowledge are found to be needed.Three layers of tools are proposed to help learn about them. The bottom-most layer of tools consists of experiential tools that can be used in different ways: freely; with fixed-content worksheets; or under guidance from the topmost knowledge-based layer.

2.1 Primitive materials layer

1/ A direct manipulation environment ("2D harmony space") for experimenting with harmonic relationships will be provided as discussed in (Holland 86) . The amateur can analyse, amend and sketch chord sequences and should be able to understand and control chord progression, chord quality and modulation from simple experiments. The environment can be used on its own; using simple fixed exercises without tutorial guidance; or the ICAI component can construct exercises for the amateur to carry out in the environment with the system inspecting results.

2/ A direct manipulation environment for specifying and exploring rhythmic patterns based on the notion of hierarchical metre as characterised by Lerdahl and Jackendoff (1983) using a simple visual metaphor will be provided. (The term "metre" refers to layers of regular pulses found in music at levels corresponding to, for example, eighth notes, quarter notes, half-bar lines, bar lines, two bar lines etc.) The tool allows rhythmic motifs or other musical events to be "scaled" and propagated at any metrical level. Such operations can be easily used to set up patterns of rhythmic accompaniment or simple repetitive musical forms. This component can be viewed as a musical editor in which hierarchical metre is used with a simple visual metaphor to delimit scope for editing, scaling and propagation operations. Work by Jean Bamberger (1974) using a single-level representation of metre suggests that such an environment should be a good source of insights into how metre interacts with phrasing, and that such insights play a vital part in understanding musical structure. This component does not necessarily include tutorial guidance, but once again, the ICAI component can construct exercises to be carried out in this component. Note that this tool, though useful, does not begin to address the full subtleties of rhythm.

3/ (For completeness, a component is needed here for the direct manipulation of different melodic strategies, but time limitations are at present restricting work on this component. It appears that a tool could be designed using the key musical idea of trajectory (i.e scalic movement towards a target note) (Levitt, 85) , and the knowledge representation method of propagation of symbolic constraints (i.e. a kind of musical spreadsheet). Much of theoretical work for such a system has been done by (Levitt, 85) but the design of good human machine interfaces for controlling such systems, especially for use by novices, remains an open research problem.)

2.2 Musical ideas direct manipulation layer.

This layer is conceptually the simplest of all, although its content might get very complex - Music Logo (see (Bamberger, 86), (Orlarey 86), (Desain and Honing, 86) and (Greenberg 86)). In a Music Logo, trees of functions can be assembled to model musical ideas of varying degrees of complexity. It is intended ultimately to provide a simple direct manipulation iconic interface in which boxes (representing functions) with funnels (representing arguments and outputs) are bolted together. This does not imply a data-flow model of time; time will be represented as line intervals given as input arguments. Both the basic materials layers below and the ICAI layer above could be used as sources of input to this layer - musical ideas assembled in the Music Logo component could become part of the linked frame system used by the ICAI layer. The Logo is to be available for unguided use, and as with the other lower layers, the ICAI component could construct exercises to be carried out in the Logo layer.

2.3 Knowledge-based layer

The topmost layer, the tutor, requires a linked set of active objects or frames (the two

terms are used synonymously here) representing knowledge about a wide range of musical items. Kinds of frames needed (with much overlapping) include:-

1/ Primitive pitch, rhythm and harmonic **materials**.

2/ Primitive **devices** and techniques used in composition such as melodic trajectory, harmonic progression in cycle of fifths and phrasing functions of rhythm.

3/ **Heuristics** and tricks (of the sort found in "how to" music books) for combining primitive material and devices in interesting ways.

4/ Broad **frameworks** in which to construct pieces (e.g. thread a chord sequence with a melody, have voices imitate each other, stack functional layers, stack ostinati (Reck,77)).

5/ Different ways to construct a piece in terms of a **goal or script** (e.g. begin predictably, thwart prediction, make it retrospectively clear why prediction was thwarted (adaption of (Levitt, 81)).

6/ **Resynthesised versions of** fragments or aspects of complete **pieces**, broken down as far as possible into melodic, harmonic and rhythmic materials, devices and strategies.

7/ **Partial characterisations of styles** represented as in the previous item (Jones, 86) (Bamberger,86) etc). It should be noted that the models to be used here are aimed at engaging amateurs' interest, not necessarily at scholarly correctness.

Objects are linked by partial order relations of specificity and generality and by a similarity net. Attached procedures can carry out tasks such as compose fragments in a given style or construct teaching exercises using specified material when asked. As well as carrying out suggested exercises, the student can browse and fill in slots or create new frames under his own direction. The activity of filling slots corresponds to the student composing new pieces, fragments, strategies or devices and finding links between existing objects. In addition to pre-existing links , the student's subjective judgement of where similarity and specificity and generality links should be forms part of the student model and should be recorded separately. Example frames will be shown in the presentation and their interaction in an imaginary scenario will be examined.

2.4 User model

A user model is held, consisting of an agenda of the user's stated and inferred goals, and two kinds of overlay. Both overlays are of musical material represented both as

wholes and as components. One overlay represents the student's skills, and another music he enjoys. As outlined above, the latter is used to help construct enjoyable intermediate goals and exercises.

3 What the research doesn't do

1/ This is not a tutor for precisely constrained tasks with clear cut goals like traditional four-part harmonisation or sixteenth century counterpoint. Tutors for this sort of task can employ traditional ICAI expert-based or bug-based approaches for tutoring a closed set of rules for a precisely defined goal. Examples of intelligent tutors for such tasks include VIVACE (actually an expert component for such a tutor) (Thomas, 85) and LASSO (Newcomb, 85).

2/ This research is not designed as an assistant or environment e.g. (Lerdahl and Potard, 83) and (Pope, 86) for practised composers who already have well-developed compositional skills and strategies. They need tools but not guidance on how to compose .

3/ The tutor cannot be expected to be able to compose good music, or teach detailed stylistics, but can be expected to be able to compose music tolerable in small doses, and reproduce styles roughly but not closely. To reproduce a style closely currently requires enormous effort and computational resources, two of the most notable efforts being Ebcioglu (1986) on Bach and Fry (1984) on John Coltrane. Local features of style can be reproduced surprisingly accurately using constraint propagation techniques for music (Levitt (85) on Mozart and Fats Waller). Good first-order approximations of styles can be represented very economically using stochastic methods in structured frameworks e.g. (Jones, 86) .

4/ Can the tutor tell the difference between good and bad music? No. But in certain circumstances to a certain limited extent (especially if a piece has been assembled using devices and materials from existing frames, or is amenable to simple analysis techniques (e.g. Winograd 68) it can detect the presence or absence of strategic, technical, stylistic and material features.

4 What's in it for ICAI?

1/ An amateur composer is by definition one who composes for love. In order to be effective, a tutor for amateur composers **must** take into account in depth not only the amateur's skills and errors , but personal likes, dislikes and interests. The system proposed is not the only ICAI system in which a user's preferences play a key role (see (Rich, 79) and (Goldstein, 82) but it is unusual in that preferences play a key role in

parallel with the more traditional skills, bugs and core curriculum when dynamically constructing teaching plans.

2/ It is unusual for an ICAI system to try to tackle a domain with the wide range, loose definition and malleability of goals found in music composition. The goal of a composition can vary from composer to composer, occasion to occasion and can be very hard to state precisely; perhaps "Compose an interesting piece of music" is one of the few generally stateable goals (see (Levitt, 81). In practice, the goal for a particular piece of music must be more preciseiy defined either by natural limitation (e.g. of technique or style) or by deliberate limitation of resources (a frequently used technique in the arts).

3/ This is an ICAI systems making heavy use of a non-text, non-visual communication medium (sound and music).

Implementation plans

Implementation begins June 87, and a year is available to implement. The system is ambitious and is only expected to be partly implemented within that time. The essential priorities are to implement 2D harmony space, the rhythm machine, a nucleus of example models of musical ideas in Logo (initially without the iconic interface), a useable nucleus of domain knowledge frames, and at least one teaching strategy. An early prototype of harmony space was implemented in Common Lisp using the interface design tool Dialog© on an Apollo Domain workstation controlling a Yamaha TX816 synthesizer via a Hinton MIDIC RS232 to MIDI converter in Jan 1987. It is intended to make further rapid prototypes of all components and try them out with novices as early as possible.

Problems

1/ The crudity of existing attempts to formalise musical "knowledge" (despite some spectacular and honourable successes).

2/ The vast size of the "space" of music composition, even when limited to a small number of areas of music. It is not yet clear to what extent a manageably small number of domain models, concepts and heuristics with sufficient generality will have reasonable competence for a range of tasks.

3/ The difficulty of keeping track of what the user is learning.

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